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Annular Heat Transfer Studies
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I. The Problem Under Consideration

Attention to date has focused on the problem of heat transfer in the entrance region of an annulus with simultaneously developing velocity and temperature profiles. The general approach is a numerical solution of the boundary layer equations. This represents the first solution of the heat transfer problem which retains the non-linear terms in the equation of motion.

II. Accomplishments to Date

Finite difference approximations have been formulated for the equations of continuity, motion and energy. A scheme for solving the resulting algebraic equations has been programmed and a few results are now available.

Figure I shows the developing velocity profiles for a ratio of inner to outer radius, k, of 0.5. It can be seen that the well known fully developed profile is achieved. This, together with the reasonable pressure drop and entrance length and the behavior of the normal component of velocity, indicates that the solution is satisfactory.

This velocity profile has been used in the energy equation to obtain Nusselt numbers (dimensionless heat transfer coefficients) as a function of distance down the conduit. The boundary conditions employed were constant heat flux at the inner surface, insulation at the outer. The results are shown in Figure II for Prandtl numbers of 0.01, 0.7 and 10.0. The results appear quite satisfactory. The correct fully developed solution is obtained and the checks with the linearized solutions indicate close agreement except very near the inlet where there is some divergence as should be expected.

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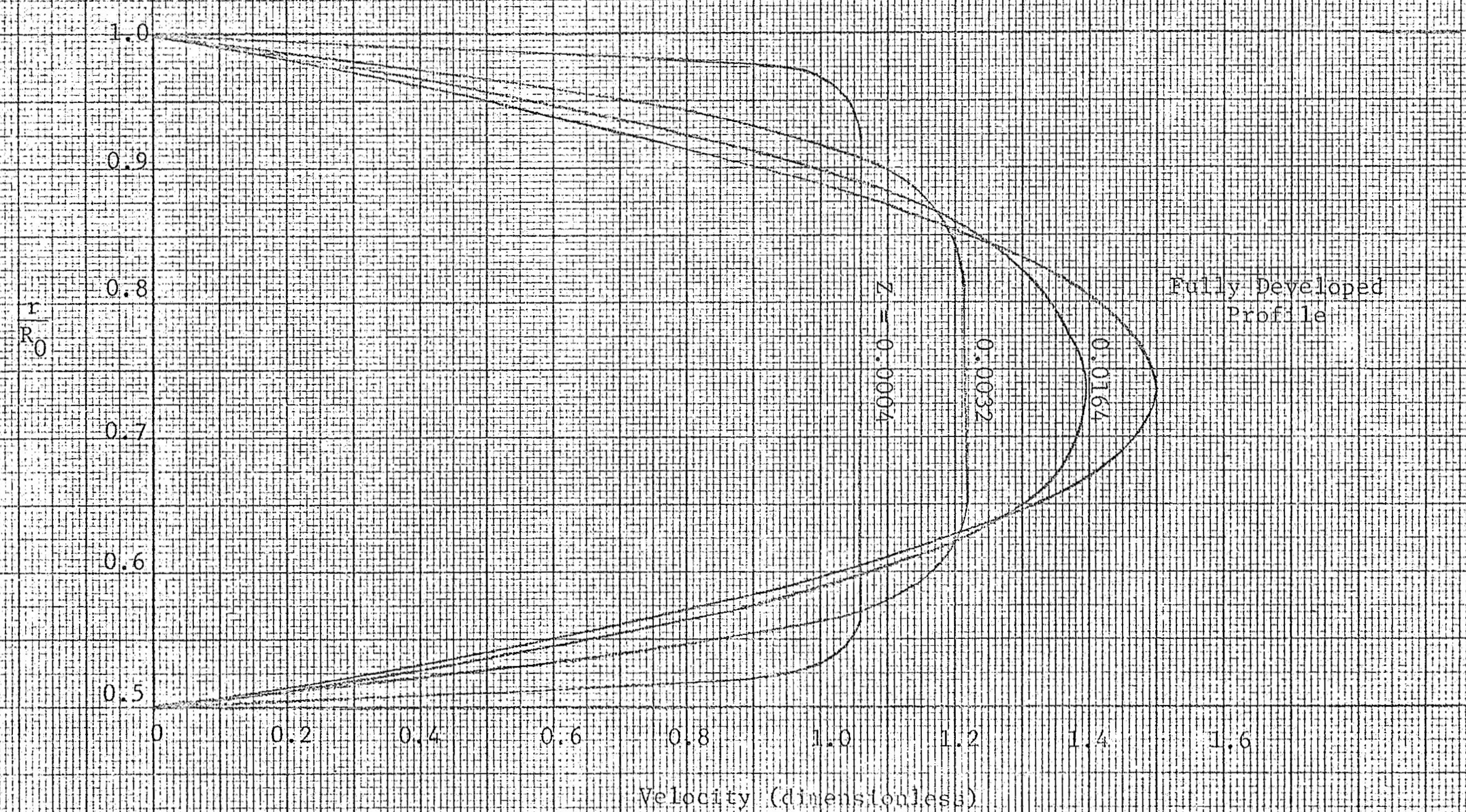

FIGURE 1. THE DEVELOPING VELOCITY PROFILE

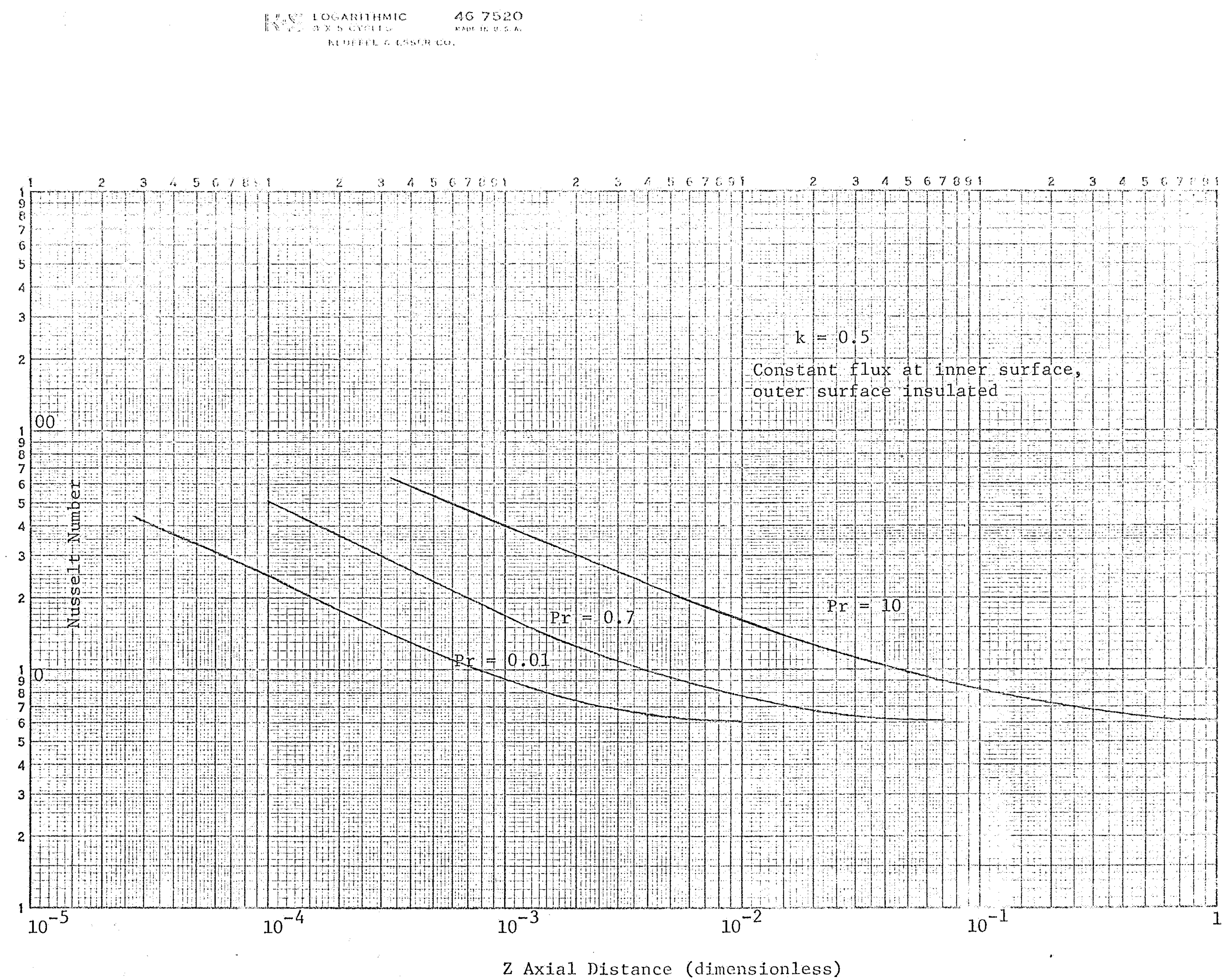
k = 0.5
Constant flux at inner surface,
outer surface insulated
Pr = 10
Pr = 0.7
Pr = 0.01
Nusselt Number
100
10
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
Z Axial Distance (dimensionless)

FIGURE II

III. Completion of This Phase of the Work

Successful completion of this phase of the work depends upon the results obtained for the cases where k has value lower than 0.5. It is in this region where curvature becomes important and where the linearized solutions can be expected to fail. This is also the region that presents the severest test of the numerical procedures. Calculations for the case k = 0.1 are in progress.

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